(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 March 2001 (15.03.2001)

PCT

(10) International Publication Number
WO 01/17920 A1

(51) International Patent Classification[7]: C03C 3/087, 4/02, 4/08

(21) International Application Number: PCT/US00/22558

(22) International Filing Date: 17 August 2000 (17.08.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/389,840 3 September 1999 (03.09.1999) US

(71) Applicant: **PPG INDUSTRIES OHIO, INC.** [US/US]; 3800 West 143rd Street, Cleveland, OH 44411 (US).

(72) Inventors: **SHELESTAK, Larry, J.**; 1046 Ford Street, P.O. Box 233, Bairdford, PA 15006 (US). **HEITHOFF, Robert, B.**; 2403 Delo Drive, Gibsonia, PA 15044 (US). **CALABRESE, Andrew**; 2614 Fountain Hills Drive, Wexford, PA 15090 (US). **KRUMWIEDE, John, F.**; 315 Blue Run Road, Cheswick, PA 15024 (US). **LONGOBARDO, Anthony, V.**; R.D. #5 Box 469, Mt. Pleasant, PA 15666 (US).

(74) Agents: **STACHEL, Kenneth, J.**; PPG Industries, Inc., One PPG Place, Pittsburgh, PA 15272 et al. (US).

(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 01/17920 A1

(54) Title: GREEN PRIVACY GLASS

(57) **Abstract:** The present invention provides a green colored, infrared and ultraviolet absorbing glass article having a luminous transmittance of up to 60 percent. The composition of the glass article uses a standard soda-lime-silica glass base composition and additionally iron, cobalt, selenium, and chromium, and optionally titanium, as infrared and ultraviolet radiation absorbing materials and colorants. The glasses of the present invention have a color characterized by a dominant wavelength in the range of about 480 to 565 nanometers, preferably about 495 to 560 nanometers, with an excitation purity of no higher than about 20 percent, preferably no higher than about 10 percent, and more preferably no higher than about 7 percent. The glass compositions may be provided with different levels of spectral performance depending on the particular application and desired luminous transmittance. In one embodiment of the invention, the glass composition of a green colored, infrared and ultraviolet radiation absorbing soda-lime-silica glass article includes a solar radiation absorbing and colorant portion comprising of about 0.60 to 4 percent by weight total iron, about 0.13 to 0.9 percent by weight FeO, about 40 to 500 PPM CoO, about 5 to 70 PPM Se, about 15 to 800 PPM Cr_2O_3, and about 0.02 to 1 percent by weight TiO_2. In another embodiment of the invention, the glass composition of the article includes a solar radiation absorbing and colorant portion consisting essentially of 1 to less than 1.4 percent by weight total iron, about 0.2 to 0.6 percent by weight FeO, greater than 200 to about 500 PPM CoO, about 5 to 70 PPM Se, greater than 200 to about 800 PPM Cr_2O_3, and 0 to about 1 percent by weight TiO_2.

GREEN PRIVACY GLASS

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of U.S. Application Serial No. 08/869221 filed June 4, 1997, which claimed the benefit of U.S. Provisional Application No. 60/021,034, filed July 2, 1996.

BACKGROUND OF THE INVENTION

This invention relates to a tinted, green colored soda-lime-silica glass having a low luminous transmittance that makes it highly desirable for use as a privacy glazing in vehicles, such as the side and rear windows in vans. In particular, the glass has a luminous transmittance of 60% or less, preferably between about 10 to 40%. As used herein, the term "green colored" is meant to include glasses that have a dominant wavelength of about 480 to 565 nanometers (nm) and may be characterized as green blue, green yellow or green gray in color. In addition, the glass of the present invention generally exhibits lower infrared and ultraviolet radiation transmittance when compared to typical green glasses used in automotive applications. The glass is also compatible with float glass manufacturing methods.

Various dark tinted, infrared and ultraviolet radiation absorbing glass compositions are known in the art. The primary colorant in typical dark tinted automotive privacy glasses is iron, which is usually present in both the Fe_2O_3 and FeO forms. Some glasses use cobalt, selenium and, optionally, nickel in combination with iron to further control infrared and ultraviolet radiation and color, for example as disclosed in U.S. Patent Nos. 4,873,206 to Jones; 5,278,108 to Cheng et al.; 5,308,805 to Baker et al.; and 5,393,593 to Gulotta et al., and European Patent application EP 0 705 800. Others also include chromium with this combination of colorants as disclosed in U.S. Patent Nos. 4,104,076 to Pons; 4,339,541 to Dela Ruye; 5,023,210 to Krumwiede et al; and 5,352,640 to Combes et al.; European Patent application EP 0 536 049; French Patent 2,331,527 and Canadian Patent 2,148,954. Still, other glasses may include additional materials, such as

disclosed in WO 96/00194, which teaches the inclusion of fluorine, zirconium, zinc, cerium, titanium and copper in the glass composition and requires that the sum of the alkaline earth oxides be less than 10 wt.% of the glass.

In producing infrared and ultraviolet radiation absorbing glasses, the relative amounts of iron and other additives must be closely monitored and controlled within an operating range to provide the desired color and spectral properties. It would be desirable to have a dark tinted green colored glass that may be used as a privacy glazing for vehicles to complement the green colored glasses typically used in automobiles that exhibits superior solar performance properties and is compatible with commercial float glass manufacturing techniques.

SUMMARY OF THE INVENTION

The present invention provides a green colored, infrared and ultraviolet absorbing glass article having a luminous transmittance of up to 60 percent. The composition of the glass article uses a standard soda-lime-silica glass base composition and additionally iron, cobalt, selenium, and chromium, and optionally titanium, as infrared and ultraviolet radiation absorbing materials and colorants. The glasses of the present invention have a color characterized by a dominant wavelength in the range of about 480 to 565 nanometers, preferably about 495 to 560 nanometers, with an excitation purity of no higher than about 20%, preferably no higher than about 10%, and more preferably no higher than about 7%. The glass compositions may be provided with different levels of spectral performance depending on the particular application and desired luminous transmittance.

In one embodiment of the invention, the glass composition of a green colored, infrared and ultraviolet radiation absorbing soda-lime-silica glass article includes a solar radiation absorbing and colorant portion having about 0.60 to 4 percent by weight total iron, about 0.13 to 0.9 percent by

weight FeO, about 40 to 500 PPM CoO, about 5 to 70 PPM Se, about 15 to 800 PPM Cr_2O_3, and about 0.02 to 1 percent by weight TiO_2. In another embodiment of the invention, the glass composition of the article includes a solar radiation absorbing and colorant portion having 1 to less than 1.4 percent by weight total iron, about 0.2 to 0.6 percent by weight FeO, greater than 200 to about 500 PPM CoO, about 5 to 70 PPM Se, greater than 200 to about 800 PPM Cr_2O_3, and 0 to about 1 percent by weight TiO_2.

DETAILED DESCRIPTION OF THE INVENTION

The base glass of the present invention, that is, the primary constituents of the glass without infrared or ultraviolet absorbing materials and/or colorants, which are the object of the present invention, is commercial soda-lime-silica glass characterized as follows:

	Weight Percent
SiO_2	66-75
Na_2O	10-20
CaO	5-15
MgO	0-5
Al_2O_3	0-5
K_2O	0-5

As used herein, all "weight percent (wt.%)" values are based on the total weight of the final glass composition.

To this base glass, the present invention adds infrared and ultraviolet radiation absorbing materials and colorants in the form of iron, cobalt, selenium, chromium and, optionally, titanium. As disclosed herein, iron is expressed in terms of Fe_2O_3 and FeO, cobalt is expressed in terms of CoO, selenium is expressed in terms of elemental Se, chromium is expressed in terms of Cr_2O_3 and titanium is expressed in terms of TiO_2. These materials and colorants preferably constitute the major colorants derived from additions to the batch materials for melting to make up the major portion of the infrared and ultraviolet radiation absorbing materials and colorants

through out the glass composition rather than just on or near one or more surfaces of the form or structure of the glass composition. Although it should be appreciated that the glass compositions disclosed herein may include small amounts of other materials or materials formed in-situ during melting that may affect the color of the glass composition. An example of these includes some melting and refining aids, tramp materials or impurities. It should be further appreciated that in one embodiment of the invention, small amounts of additional materials may be included in the glass to improve the solar performance of the glass as will be discussed later in more detail. Most preferably the glass composition is essentially free of other major colorants. The glass composition of the present invention is preferably essentially free of materials added to the batch to result in the glass composition having fluorine, and oxides of zirconium, cesium, boron, and barium. In one embodiment the transition metals and oxides for the major colorants consist essentially of iron, cobalt, selenium, chromium and, optionally, titanium.

The iron oxides in a glass composition perform several functions. Ferric oxide, Fe_2O_3, is a strong ultraviolet radiation absorber and operates as a yellow colorant in the glass. Ferrous oxide, FeO, is a strong infrared radiation absorber and operates as a blue colorant. The total amount of iron present in the glasses disclosed herein is expressed in terms of Fe_2O_3 in accordance with standard analytical practice but that does not imply that all of the iron is actually in the form of Fe_2O_3. Likewise, the amount of iron in the ferrous state is reported as FeO, even though it may not actually be present in the glass as FeO. In order to reflect the relative amounts of ferrous and ferric iron in the glass compositions disclosed herein, the term "redox" shall mean the amount of iron in the ferrous state (expressed as FeO) divided by the amount of total iron (expressed as Fe_2O_3). Furthermore, unless stated otherwise, the term "total iron" in this specification

shall mean total iron expressed in terms of Fe_2O_3 and the term "FeO" shall mean iron in the ferrous state expressed in terms of FeO.

Se is an ultraviolet and infrared radiation absorbing colorant that imparts a pink or brown color to soda-lime-silica glass. Se may also absorb some infrared radiation and its use tends to decrease redox. CoO operates as a blue colorant and does not exhibit any appreciable ultraviolet or infrared radiation absorbing properties. Cr_2O_3 imparts a green color to the glass and helps control the final glass color. It is believed that the chromium may also provide some ultraviolet radiation absorption. TiO_2 is an ultraviolet radiation absorber that operates as a colorant imparting a yellow color to the glass composition. A proper balance between the iron, i.e. ferric and ferrous oxides, chromium, selenium, cobalt and optionally titanium content is required to obtain the desired green colored privacy glass with the desired spectral properties.

The glass of the present invention may be melted and refined in a continuous, large-scale, commercial melting operation and formed into flat glass sheets of varying thicknesses by the float method in which the molten glass is supported on a pool of molten metal, usually tin, as it assumes a ribbon shape and is cooled. It should be appreciated that as a result of forming the glass on molten tin, measurable amounts of tin oxide may migrate into surface portions of the glass on the side that was in contact with the tin. Typically, a piece of float glass has an SnO_2 concentration of at least 0.05 to 2 wt.% in the first 25 microns below the surface of the glass that was in contact with the tin. Typical background levels of SnO_2 may be as high as 30 parts per million (PPM). It is believed without limiting the invention that high tin concentrations in about the first 10 angstroms of the glass surface supported by the molten tin may slightly increase the reflectivity of that

glass surface; however, the overall impact on the glass properties is minimal.

The melting and forming arrangements used to produce the glass compositions of the present invention include, but are not limited to a conventional, overhead fired continuous melting operation, as is well known in the art, or a multi-stage melting operation, as disclosed in U.S. Patent Nos. 4,381,934 to Kunkle et al.; 4,792,536 to Pecoraro et al. and 4,886,539 to Cerutti et al. If required, a stirring arrangement may be employed within the melting and/or forming stages of the glass production operation to homogenize the glass in order to produce glass of the highest optical quality.

Tables 1, 2 and 3 illustrate examples of glass compositions which embody the principles of the present invention. The examples in Tables 1 and 2 are computer modeled compositions generated by a glass color and spectral performance computer model developed by PPG Industries, Inc. The examples in Table 3 are actual experimental laboratory melts. The spectral properties shown for Tables 1 and 3 are based on a reference thickness of 0.160 inches (4.06 mm) and those in Table 2 are based on a reference thickness of 0.154 inches (3.91 mm). For comparison purposes, the spectral properties of the examples may be approximated at different thicknesses using the formulas disclosed in U.S. Patent No. 4,792,536. Only the iron, cobalt, selenium, chromium and titanium portions of the examples are listed in the tables. With respect to the transmittance data provided in the tables, the luminous transmittance (LTA) is measured using C.I.E. standard illuminant "A" with a 2° observer over the wavelength range 380 to 770 nanometers and glass color, in terms of dominant wavelength and excitation purity, is measured using C.I.E. standard illuminant "C" with a 2° observer, following the procedures established in ASTM E308-90. The total solar ultraviolet transmittance (TSUV) is measured over the wavelength range 300 to 400 nanometers, total solar infrared

transmittance (TSIR) is measured over the wavelength range 720 to 2000 nanometers, and total solar energy transmittance (TSET) is measured over the wavelength range 300 to 2000 nanometers. The TSUV, TSIR and TSET transmittance data are calculated using Parry Moon air mass 2.0 direct solar irradiance data and integrated using the Trapezoidal Rule, as is known in the art.

The optical properties reported in Tables 1 and 2 are the expected properties of a glass having a base glass composition and colorants, generally as discussed herein, based upon the absorption coefficients of the glass' constituents, assuming that the glass is homogeneous throughout and is manufactured by a conventional float glass process, as is well known in the art.

The information provided in Table 3 is based on experimental laboratory melts having approximately the following batch components:

cullet A	125 gm
cullet B	22.32 gm
cullet C	8.93 gm
rouge	0.32 gm
Cr_2O_3	0.0461 gm
TiO_2	0.3-0.6 gm
Se	0.0037-0.0073 gm
graphite	0.015 gm

The cullets used in the melts included varying amounts of iron, cobalt, selenium, chromium and/or titanium. More specifically, cullet A included 0.811 wt.% total iron, 0.212 wt.% FeO, 101 PPM CoO, 17 PPM Se, 8 PPM Cr_2O_3, and 0.02 wt.% TiO_2. Cullet B included 1.417 wt.% total iron, 0.362 wt.% FeO, 211.25 PPM CoO, 25 PPM Se, and 7.5 PPM Cr_2O_3. Cullet C included 0.93 wt.% total iron, 0.24 wt.% FeO, 6 PPM Cr_2O_3, and 0.02 wt.% TiO_2. In preparing the melts, the ingredients were weighed out and mixed. It is believed that the material was then placed in a 4-inch platinum crucible and heated to 2600°F (1427°C) for 30 minutes and then heated to 2650°F (1454°C) for

1 hour. Next, the molten glass was fritted in water, dried, put in a 2-inch platinum crucible and reheated at 2650°F (1454°C) for at least 1 hour. The molten glass was then poured out of the crucible to form a slab and annealed. Samples were cut from the slab and ground and polished for analysis. The chemical analysis of the glass compositions was determined using a RIGAKU 3370 X-ray fluorescence spectrophotometer. The FeO content was determined using wet chemistry techniques, as is well known in the art. The spectral characteristics of the glass were determined on annealed samples using a Perkin-Elmer Lambda 9 UV/VIS/NIR spectrophotometer prior to tempering the glass or prolonged exposure to ultraviolet radiation, which will effect the spectral properties of the glass.

The following is representative of the basic oxides of the particular experimental melts disclosed in Table 3, which also fall within the base glass composition discussed earlier:

SiO_2	70-72 wt.%
Na_2O	12-14 wt.%
CaO	8-10 wt.%
MgO	3-4 wt.%
Al_2O_3	0.1-0.6 wt.%
K_2O	0.01-0.15 wt.%

The analysis of these melts also showed that the glasses included about 0.081 wt.% MnO_2. It is presumed that the MnO_2 entered into the glass melt as part of the cullet.

TABLE 1

	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6	Ex. 7	Ex. 8	Ex. 9	Ex. 10	Ex. 11	Ex. 12
FeO (wt.%)	0.4320	0.5580	0.7240	0.4775	0.5225	0.5143	0.5670	0.6545	0.6110	0.4725	0.6938	0.5980
Total iron (wt.%)	1.920	1.860	1.810	1.910	1.900	1.870	1.890	1.870	1.880	1.890	1.850	1.840
Model redox	0.2250	0.3000	0.4000	0.2500	0.2750	0.2750	0.3000	0.3500	0.3250	0.2500	0.3750	0.3250
Cr2O3 (wt.%)	0.0365	0.0350	0.0350	0.0365	0.0365	0.0340	0.0365	0.0370	0.0365	0.0350	0.0370	0.0355
CoO (wt.%)	0.0391	0.0356	0.0310	0.0377	0.0364	0.0370	0.0351	0.0326	0.0338	0.0379	0.0314	0.0344
Se (wt.%)	0.0047	0.0050	0.0054	0.0048	0.0049	0.0048	0.0050	0.0052	0.0051	0.0047	0.0053	0.0050
TiO2 (wt.%)		0.1800	0.2400			0.4900				0.3400		0.4400
LTA (%)	5.02	5.04	5.05	5.05	5.06	5.08	5.08	5.10	5.10	5.12	5.12	5.13
TSUV (%)	2.48	2.88	3.58	2.62	2.77	2.59	2.94	3.29	3.11	2.52	3.51	2.95
TSIR (%)	7.28	3.84	1.73	5.76	4.59	4.78	3.68	2.41	2.97	5.91	2.00	3.16
TSET (%)	6.33	4.42	3.18	5.50	4.85	4.96	4.33	3.60	3.93	5.61	3.37	4.05
DW (nm)	551.02	550.90	550.96	551.29	550.79	550.61	550.68	550.52	550.92	550.76	550.81	550.64
Pe (%)	3.58	3.57	3.62	3.72	3.72	3.85	3.76	3.85	3.84	3.86	3.83	3.98

TABLE 1 (cont.)

	Ex. 13	Ex. 14	Ex. 15	Ex. 16	Ex. 17	Ex. 18	Ex. 19	Ex. 20	Ex. 21	Ex. 22	Ex. 23	Ex. 24
FeO (wt.%)	0.7360	0.4298	0.6825	0.6405	0.3860	0.3860	0.3750	0.3750	0.8750	0.3750	0.8125	0.3750
Total iron (wt.%)	1.840	1.910	1.820	1.830	1.930	1.930	1.500	1.500	3.500	1.500	3.250	1.500
Model redox	0.4000	0.2250	0.3750	0.3500	0.2000	0.2000	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
Cr2O3 (wt.%)	0.0370	0.0340	0.0340	0.0345	0.0375	0.0330	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250
CoO (wt.%)	0.0302	0.0390	0.0320	0.0330	0.0398	0.0400	0.0450	0.0400	0.0220	0.0220	0.0220	0.0350
Se (wt.%)	0.0054	0.0046	0.0052	0.0051	0.0045	0.0044	0.0027	0.0027	0.0027	0.0060	0.0027	0.0027
TiO2 (wt.%)		0.2600	0.4500	0.3900		0.3900	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	5.13	5.15	5.16	5.19	5.20	5.28	6.54	7.80	8.59	8.73	9.20	9.33
TSUV (%)	3.72	2.41	3.29	3.16	2.40	2.24	6.17	6.21	1.07	2.86	1.32	6.24
TSIR (%)	1.64	7.38	2.11	2.58	9.28	9.29	9.94	9.99	0.89	9.98	1.18	10.04
TSET (%)	3.16	6.44	3.44	3.73	7.50	7.54	9.18	9.65	3.64	9.09	4.10	10.20
DW (nm)	551.01	550.93	550.70	550.93	550.63	550.86	478.05	479.92	549.82	581.29	549.90	482.49
Pe (%)	3.86	3.70	3.89	3.92	3.76	3.89	30.19	23.61	18.23	38.27	16.69	16.75

TABLE 1 (cont.)

	Ex. 25	Ex. 26	Ex. 27	Ex. 28	Ex. 29	Ex. 30	Ex. 31	Ex. 32	Ex. 33	Ex. 34	Ex. 35	Ex. 36
FeO (wt.%)	0.375	0.75	0.225	0.6875	0.375	0.175	0.375	0.625	0.5625	0.375	0.225	0.5
Total iron (wt.%)	1.5000	3.0000	0.9000	2.7500	1.5000	0.7000	1.5000	2.5000	2.2500	1.5000	0.9000	2.0000
Model redox	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
Cr2O3 (wt.%)	0.0250	0.0250	0.0250	0.0250	0.0250	0.0210	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250
CoO (wt.%)	0.0220	0.0220	0.0450	0.0220	0.0220	0.0450	0.0300	0.0220	0.0220	0.0220	0.0400	0.0220
Se (wt.%)	0.0053	0.0027	0.0017	0.0027	0.0046	0.0011	0.0027	0.0027	0.0027	0.0039	0.0017	0.0027
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	9.74	9.86	10.49	10.56	10.90	10.99	11.19	11.33	12.15	12.23	12.42	13.04
TSUV (%)	3.39	1.62	18.98	2.00	4.01	26.80	6.28	2.49	3.11	4.74	19.09	3.91
TSIR (%)	10.02	1.58	23.31	2.11	10.06	30.76	10.09	2.85	3.88	10.10	23.41	5.30
TSET (%)	9.54	4.64	19.61	5.29	10.08	24.75	10.84	6.09	7.09	10.72	20.37	8.36
DW (nm)	579.72	549.97	474.57	550.01	577.57	473.07	487.02	550.02	549.99	574.14	475.74	549.87
Pe (%)	31.58	15.12	43.48	13.51	24.63	50.78	9.78	11.87	10.21	17.48	37.70	8.51

TABLE 1 (cont.)

	Ex. 37	Ex. 38	Ex. 39	Ex. 40	Ex. 41	Ex. 42	Ex. 43	Ex. 44	Ex. 45	Ex. 46	Ex. 47	Ex. 48
FeO (wt.%)	0.6	0.175	0.375	0.5625	0.375	0.375	0.525	0.375	0.375	0.4375	0.4875	0.375
Total iron (wt.%)	1.500	0.700	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.750	1.500	1.500
Model redox	0.4000	0.2500	0.2500	0.3750	0.2500	0.2500	0.3500	0.2500	0.2500	0.2500	0.3250	0.2500
Cr2O3 (wt.%)	0.0250	0.0210	0.0800	0.0250	0.0250	0.0700	0.0250	0.0250	0.0600	0.0250	0.0250	0.0500
CoO (wt.%)	0.0220	0.0400	0.0220	0.0220	0.0250	0.0220	0.0220	0.0220	0.0220	0.0220	0.0220	0.0220
Se (wt.%)	0.0027	0.0011	0.0027	0.0027	0.0027	0.0027	0.0027	0.0032	0.0027	0.0027	0.0027	0.0027
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	13.10	13.12	13.23	13.40	13.45	13.53	13.70	13.78	13.85	14.00	14.02	14.17
TSUV (%)	9.03	26.97	6.09	8.50	6.31	6.13	8.00	5.62	6.18	4.96	7.54	6.22
TSIR (%)	3.24	30.90	10.05	3.89	10.14	10.07	4.69	10.14	10.09	7.31	5.66	10.11
TSET (%)	7.78	25.64	10.89	8.22	11.61	11.10	8.74	11.50	11.31	10.00	9.37	11.54
DW (nm)	488.02	474.18	554.18	489.76	502.78	553.79	492.18	566.66	553.27	549.62	496.03	552.58
Pe (%)	11.44	45.13	12.49	9.38	3.22	11.14	7.32	10.21	9.78	6.79	5.31	8.43

TABLE 1 (cont.)

	Ex. 49	Ex. 50	Ex. 51	Ex. 52	Ex. 53	Ex. 54	Ex. 55	Ex. 56	Ex. 57	Ex. 58	Ex. 59	Ex. 60
FeO (wt.%)	0.4500	0.3750	0.4125	0.2250	0.3750	0.3750	0.3750	0.3750	0.3750	0.3750	0.2948	0.3750
Total iron (wt.%)	1.500	1.500	1.500	0.900	1.500	1.500	1.500	1.500	1.500	1.500	1.310	1.500
Model redox	0.3000	0.2500	0.2750	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2250	0.2500
Cr2O3 (wt.%)	0.0250	0.0400	0.0250	0.0250	0.0300	0.0250	0.0250	0.0250	0.0250	0.0250	0.0280	0.0250
CoO (wt.%)	0.0220	0.0220	0.0220	0.0350	0.0220	0.0220	0.0220	0.0220	0.0220	0.0220	0.0235	0.0220
Se (wt.%)	0.0027	0.0027	0.0027	0.0017	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0028	0.0027
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.8000	0.7000	0.6000	0.5000	0.4000		0.3000
LTA (%)	14.34	14.51	14.68	14.74	14.86	14.90	14.93	14.95	14.97	14.99	15.01	15.01
TSUV (%)	7.11	6.27	6.71	19.20	6.31	5.44	5.58	5.72	5.87	6.02	7.47	6.18
TSIR (%)	6.86	10.14	8.34	23.52	10.16	10.17	10.17	10.17	10.17	10.17	15.69	10.17
TSET (%)	10.12	11.77	11.04	21.26	12.02	11.97	12.00	12.03	12.05	12.08	15.28	12.11
DW (nm)	503.82	551.62	525.32	477.06	550.13	558.49	557.46	556.28	554.91	553.31	550.91	551.42
Pe (%)	3.46	7.08	2.97	31.54	5.72	8.18	7.66	7.14	6.61	6.09	3.66	5.57

TABLE 1 (cont.)

	Ex. 61	Ex. 62	Ex. 63	Ex. 64	Ex. 65	Ex. 66	Ex. 67	Ex. 68	Ex. 69	Ex. 70	Ex. 71	Ex. 72
FeO (wt.%)	0.3750	0.3750	0.3750	0.3493	0.3810	0.3250	0.4960	0.4650	0.3750	0.2600	0.3750	0.2080
Total iron (wt.%)	1.500	1.500	1.500	1.270	1.270	1.300	1.240	1.240	1.500	1.300	1.500	1.280
Model redox	0.2500	0.2500	0.2500	0.2750	0.3000	0.2500	0.4000	0.3750	0.2500	0.2000	0.2500	0.2250
Cr2O3 (wt.%)	0.0250	0.0250	0.0250	0.0255	0.0260	0.0280	0.0290	0.0260	0.0250	0.0270	0.0250	0.0260
CoO (wt.%)	0.0220	0.0220	0.0220	0.0222	0.0212	0.0226	0.0178	0.0189	0.0220	0.0245	0.0220	0.0240
Se (wt.%)	0.0027	0.0027	0.0027	0.0029	0.0030	0.0029	0.0033	0.0032	0.0027	0.0027	0.0027	0.0027
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.3000	0.1500			0.2000	0.1000	0.1300	0.0200	0.4800
LTA (%)	15.04	15.04	15.04	15.04	15.05	15.05	15.05	15.06	15.06	15.07	15.08	15.08
TSUV (%)	6.34	6.34	6.34	7.81	8.35	7.82	10.25	9.45	6.50	7.10	6.63	6.98
TSIR (%)	10.17	10.17	10.17	11.67	9.85	13.30	5.43	6.36	10.17	19.02	10.17	16.29
TSET (%)	12.14	12.14	12.14	13.09	12.09	13.99	9.57	10.11	12.17	17.12	12.20	15.62
DW (nm)	549.10	549.10	549.10	550.99	550.72	550.89	551.07	550.60	546.28	550.76	543.54	550.58
Pe (%)	5.04	5.04	5.04	3.66	3.57	3.69	3.79	3.60	4.53	3.54	4.12	3.82

TABLE 1 (cont.)

	Ex. 73	Ex. 74	Ex. 75	Ex. 76	Ex. 77	Ex. 78	Ex. 79	Ex. 80	Ex. 81	Ex. 82	Ex. 83	Ex. 84
FeO (wt.%)	0.4410	0.4375	0.3200	0.3548	0.4688	0.4095	0.4960	0.3840	0.2640	0.4128	0.3750	0.3375
Total iron (wt.%)	1.260	1.250	1.280	1.290	1.250	1.260	1.240	1.280	1.320	1.270	1.500	1.500
Model redox	0.3500	0.3500	0.2500	0.2750	0.3750	0.3250	0.4000	0.3000	0.2000	0.3250	0.2500	0.2250
Cr2O3 (wt.%)	0.0290	0.0260	0.0260	0.0290	0.0290	0.0260	0.0250	0.0290	0.0280	0.0290	0.0200	0.0250
CoO (wt.%)	0.0193	0.0197	0.0230	0.0217	0.0185	0.0205	0.0182	0.0208	0.0242	0.0200	0.0220	0.0220
Se (wt.%)	0.0032	0.0031	0.0028	0.0029	0.0032	0.0030	0.0032	0.0030	0.0027	0.0031	0.0027	0.0027
TiO2 (wt.%)		0.3000	0.3500			0.3900	0.4400				0.2000	0.2000
LTA (%)	15.09	15.09	15.09	15.09	15.11	15.14	15.14	15.15	15.16	15.16	15.22	15.40
TSUV (%)	9.38	8.87	7.42	8.20	9.82	8.34	9.35	8.59	7.18	8.99	6.36	5.98
TSIR (%)	7.19	7.33	13.67	11.32	6.24	8.48	5.44	9.69	18.60	8.33	10.18	12.44
TSET (%)	10.59	10.66	14.20	12.91	10.05	11.32	9.58	12.02	16.92	11.26	12.27	13.49
DW (nm)	550.53	550.77	550.65	550.53	550.80	550.87	550.70	551.11	550.86	550.82	547.74	559.28
Pe (%)	3.77	3.79	3.76	3.79	3.80	3.95	3.93	3.89	3.70	3.85	4.37	7.45

TABLE 1 (cont.)

	Ex. 85	Ex. 86	Ex. 87	Ex. 88	Ex. 89	Ex. 90	Ex. 91	Ex. 92	Ex. 93	Ex. 94	Ex. 95	Ex. 96
FeO (wt.%)	0.3750	0.3750	0.1750	0.3000	0.3750	0.3750	0.3750	0.2250	0.3120	0.2990	0.2860	0.2990
Total iron (wt.%)	1.500	1.500	0.700	1.500	1.500	1.500	1.500	0.900	1.200	1.150	1.100	1.100
Model redox	0.2500	0.2500	0.2500	0.2000	0.2500	0.2500	0.2500	0.2500	0.2600	0.2600	0.2600	0.2720
Cr2O3 (wt.%)	0.0250	0.0100	0.0210	0.0250	0.0005	0.0250	0.0250	0.0250	0.0230	0.0280	0.0320	0.0320
CoO (wt.%)	0.0220	0.0220	0.0350	0.0220	0.0220	0.0200	0.0220	0.0300	0.0196	0.0200	0.0201	0.0198
Se (wt.%)	0.0025	0.0027	0.0011	0.0027	0.0027	0.0027	0.0020	0.0017	0.0025	0.0024	0.0025	0.0025
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.0280	0.0280	0.0280	0.0280
LTA (%)	15.58	15.59	15.72	15.78	15.95	16.20	17.04	17.54	18.03	18.05	18.02	18.06
TSUV (%)	6.65	6.40	27.14	5.65	6.45	6.35	7.50	19.31	9.55	10.19	10.64	10.87
TSIR (%)	10.18	10.21	31.05	15.27	10.23	10.19	10.22	23.63	11.9	12.88	13.95	12.88
TSET (%)	12.43	12.54	26.69	15.14	12.80	12.53	13.22	22.30	15.38	15.96	16.53	15.95
DW (nm)	528.36	543.24	475.35	564.59	533.25	560.22	496.92	478.60	556.5	547.3	549.7	545.6
Pe (%)	3.26	3.03	39.04	9.88	1.81	8.39	5.84	25.04	4.43	3.36	3.62	3.27

TABLE 1 (cont.)

	Ex. 97	Ex. 98	Ex. 99	Ex. 100	Ex. 101	Ex. 102	Ex. 103	Ex. 104	Ex. 106	Ex. 106	Ex. 107	Ex. 108
FeO (wt.%)	0.3750	0.1750	0.2250	0.3750	0.2250	0.2250	0.3750	0.1750	0.1750	0.2250	0.3750	0.1750
Total iron (wt.%)	1.500	0.700	0.900	1.500	0.900	0.900	1.500	0.700	0.700	0.900	1.500	0.700
Model redox	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
Cr2O3 (wt.%)	0.0250	0.0210	0.0250	0.0250	0.0250	0.0250	0.0250	0.0210	0.0210	0.0250	0.0250	0.0210
CoO (wt.%)	0.0220	0.0300	0.0107	0.0150	0.0250	0.0107	0.0220	0.0070	0.0250	0.0107	0.0100	0.0070
Se (wt.%)	0.0015	0.0011	0.0060	0.0027	0.0017	0.0053	0.0008	0.0060	0.0011	0.0046	0.0027	0.0053
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	18.68	18.88	19.28	19.57	20.92	21.12	21.31	21.65	22.73	23.19	23.68	23.86
TSUV (%)	8.46	27.31	7.87	6.39	19.42	9.14	10.02	9.26	27.48	10.62	6.42	10.85
TSIR (%)	10.25	31.19	23.35	10.25	23.73	23.46	10.29	31.12	31.34	23.57	10.30	31.22
TSET (%)	14.13	27.91	20.49	13.63	23.52	21.34	15.65	25.68	29.35	22.31	14.95	26.65
DW (nm)	491.19	476.64	583.88	568.92	480.62	582.85	487.95	585.96	478.18	581.60	572.24	585.04
Pe (%)	10.53	32.49	41.80	16.72	18.24	36.18	17.10	49.85	25.55	30.33	24.81	44.03

TABLE 1 (cont.)

	Ex. 109	Ex. 110	Ex. 111	Ex. 112	Ex. 113	Ex. 114	Ex. 115	Ex. 116	Ex. 117	Ex. 118	Ex. 119	Ex. 120
FeO (wt.%)	0.2250	0.2060	0.3185	0.2970	0.3600	0.2750	0.3263	0.3440	0.3395	0.2585	0.2925	0.2040
Total iron (wt.%)	0.900	1.030	0.980	0.990	0.960	1.000	0.870	0.860	0.970	0.940	0.900	1.020
Model redox	0.2500	0.2000	0.3250	0.3000	0.3750	0.2750	0.3750	0.4000	0.3500	0.2750	0.3250	0.2000
Cr2O3 (wt.%)	0.0250	0.0240	0.0240	0.0240	0.0250	0.0240	0.0270	0.0280	0.0240	0.0250	0.0260	0.0235
CoO (wt.%)	0.0200	0.0170	0.0138	0.0144	0.0126	0.0150	0.0135	0.0131	0.0132	0.0155	0.0145	0.0172
Se (wt.%)	0.0017	0.0018	0.0022	0.0021	0.0023	0.0020	0.0022	0.0022	0.0022	0.0020	0.0021	0.0018
TiO2 (wt.%)	0.2000						0.3000	0.4700		0.2600	0.3100	0.2600
LTA (%)	25.01	25.01	25.04	25.06	25.07	25.08	25.08	25.08	25.08	25.08	25.09	25.09
TSU (%)	19.53	12.29	14.95	14.39	16.20	13.84	16.42	16.44	15.57	13.87	15.07	11.78
TSIR (%)	23.84	26.16	13.98	15.73	11.18	17.75	13.41	12.18	12.48	19.46	16.12	26.47
TSET (%)	24.95	25.29	18.67	19.63	17.11	20.75	18.38	17.65	17.85	21.69	19.87	25.45
DW (nm)	483.91	550.56	551.23	551.01	550.87	551.07	550.51	550.63	550.78	550.87	550.95	550.70
Pe (%)	11.21	3.69	3.72	3.71	3.75	3.75	3.55	3.88	3.65	3.67	3.65	3.94

TABLE 1 (cont.)

	Ex. 121	Ex. 122	Ex. 123	Ex. 124	Ex. 125	Ex. 126	Ex. 127	Ex. 128	Ex. 129	Ex. 130	Ex. 131	Ex. 132
FeO (wt.%)	0.2183	0.2400	0.3800	0.2525	0.3115	0.2295	0.2760	0.2250	0.1750	0.1750	0.2250	0.4250
Total iron (wt.%)	0.970	0.960	0.950	1.010	0.890	1.020	0.920	0.900	0.700	0.700	0.900	1.700
Model redox	0.2250	0.2500	0.4000	0.2500	0.3500	0.2250	0.3000	0.2500	0.2500	0.2500	0.2500	0.2500
Cr2O3 (wt.%)	0.0230	0.0240	0.0250	0.0240	0.0270	0.0240	0.0250	0.0250	0.0210	0.0210	0.0250	0.0250
CoO (wt.%)	0.0167	0.0162	0.0120	0.0156	0.0140	0.0162	0.0150	0.0107	0.0070	0.0200	0.0107	0.0107
Se (wt.%)	0.0019	0.0019	0.0023	0.0020	0.0021	0.0019	0.0020	0.0039	0.0046	0.0011	0.0032	0.0017
TiO2 (wt.%)	0.2300	0.4200			0.4500		0.4300	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	25.09	25.10	25.13	25.15	25.17	25.19	25.27	25.52	26.35	27.45	28.15	28.38
TSUV (%)	12.79	12.80	16.85	13.34	15.24	12.83	14.09	12.33	12.71	27.65	14.33	9.99
TSIR (%)	24.41	21.59	10.06	20.12	14.53	22.90	17.66	23.68	31.33	31.49	23.80	8.20
TSET (%)	24.40	22.83	16.50	22.08	18.99	23.60	20.77	23.44	27.77	31.06	24.75	16.22
DW (nm)	550.83	550.53	551.00	550.49	550.57	551.12	550.65	579.95	584.02	480.17	577.51	545.94
Pe (%)	3.51	3.84	3.74	3.71	3.91	3.80	3.82	24.29	37.88	18.25	18.11	7.52

TABLE 1 (cont.)

	Ex. 133	Ex. 134	Ex. 135	Ex. 136	Ex. 137	Ex. 138	Ex. 139	Ex. 140	Ex. 141	Ex. 142	Ex. 143	Ex. 144
FeO (wt.%)	0.3750	0.4000	0.1750	0.3750	0.2250	0.3500	0.2250	0.2250	0.2250	0.3250	0.3600	0.2250
Total iron (wt.%)	1.500	1.600	0.700	1.500	0.900	1.400	0.900	0.900	0.900	1.300	0.900	0.900
Model redox	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.4000	0.2500
Cr2O3 (wt.%)	0.0250	0.0250	0.0210	0.0250	0.0250	0.0250	0.0800	0.0250	0.0700	0.0250	0.0250	0.0600
CoO (wt.%)	0.0050	0.0107	0.0070	0.0107	0.0150	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107
Se (wt.%)	0.0027	0.0017	0.0039	0.0017	0.0017	0.0017	0.0017	0.0025	0.0017	0.0017	0.0017	0.0017
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	28.72	29.13	29.19	29.91	29.96	30.71	30.71	31.14	31.44	31.53	32.11	32.20
TSUV (%)	6.46	10.84	14.90	11.76	19.65	12.78	19.13	16.64	19.24	13.90	23.95	19.35
TSIR (%)	10.35	9.34	31.44	10.65	23.95	12.15	23.80	23.91	23.84	13.89	11.55	23.89
TSET (%)	16.56	17.23	29.09	18.35	26.65	19.59	25.48	26.29	25.96	20.97	20.75	26.46
DW (nm)	574.22	546.65	582.80	547.43	492.96	548.31	556.15	573.03	556.08	549.30	492.90	555.97
Pe (%)	32.55	7.16	31.42	6.80	4.27	6.44	11.87	11.83	10.56	6.07	5.63	9.24

TABLE 1 (cont.)

	Ex. 145	Ex. 146	Ex. 147	Ex. 148	Ex. 149	Ex. 150	Ex. 151	Ex. 152	Ex. 153	Ex. 154	Ex. 155	Ex. 156
FeO (wt.%)	0.3000	0.1750	0.3375	0.2250	0.3150	0.1750	0.2750	0.2250	0.2925	0.2250	0.2700	0.2500
Total iron (wt.%)	1.200	0.700	0.900	0.900	0.900	0.700	1.100	0.900	0.900	0.900	0.900	1.000
Model redox	0.2500	0.2500	0.3750	0.2500	0.3500	0.2500	0.2500	0.2500	0.3250	0.2500	0.3000	0.2500
Cr2O3 (wt.%)	0.0250	0.0210	0.0250	0.0500	0.0250	0.0210	0.0250	0.0250	0.0250	0.0400	0.0250	0.0250
CoO (wt.%)	0.0107	0.0070	0.0107	0.0107	0.0107	0.0150	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107
Se (wt.%)	0.0017	0.0032	0.0017	0.0017	0.0017	0.0011	0.0017	0.0020	0.0017	0.0017	0.0017	0.0017
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	32.37	32.44	32.57	32.99	33.05	33.22	33.24	33.52	33.54	33.80	34.03	34.14
TSUV (%)	15.15	17.46	23.17	19.46	22.43	27.83	16.52	18.52	21.72	19.57	21.03	18.05
TSIR (%)	15.90	31.55	13.01	23.93	14.68	31.64	18.23	24.00	16.58	23.98	18.74	20.92
TSET (%)	22.52	30.63	21.68	26.98	22.72	33.10	24.24	27.54	23.89	27.52	25.21	26.19
DW (nm)	550.42	581.19	495.48	555.80	499.55	483.52	551.73	565.70	507.34	555.55	524.51	553.17
Pe (%)	5.71	24.72	4.48	7.93	3.37	10.68	5.36	7.33	2.42	6.61	2.27	5.00

TABLE 1 (cont.)

	Ex. 157	Ex. 158	Ex. 159	Ex. 160	Ex. 161	Ex. 162	Ex. 163	Ex. 164	Ex. 165	Ex. 166	Ex. 167	Ex. 168
FeO (wt.%)	0.2475	0.2250	0.2250	0.2250	0.2250	0.2250	0.2250	0.2250	0.3038	0.2050	0.1760	0.1680
Total iron (wt.%)	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.810	0.820	0.880	0.840
Model redox	0.2750	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.3750	0.2500	0.2000	0.2000
Cr2O3 (wt.%)	0.0250	0.0300	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0270	0.0250	0.0280	0.0270
CoO (wt.%)	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0084	0.0113	0.0119	0.0122
Se (wt.%)	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0020	0.0017	0.0016	0.0016
TiO2 (wt.%)	0.2000	0.2000	0.8000	0.7000	0.6000	0.5000	0.4000	0.3000		0.2200		0.1500
LTA (%)	34.54	34.63	34.75	34.80	34.85	34.91	34.96	35.01	35.02	35.03	35.05	35.05
TSUV (%)	20.38	19.69	16.79	17.24	17.72	18.20	18.70	19.22	24.83	21.12	20.29	20.31
TSIR (%)	21.22	24.03	24.05	24.05	24.05	24.05	24.05	24.05	15.60	26.90	31.69	33.17
TSET (%)	26.70	28.08	27.94	28.01	28.08	28.15	28.23	28.30	23.83	30.05	32.59	33.42
DW (nm)	544.21	555.15	562.59	561.76	560.81	559.69	558.39	556.81	550.61	550.96	550.65	550.80
Pe (%)	3.34	5.30	7.81	7.28	6.76	6.23	5.70	5.17	3.72	3.47	3.73	3.55

TABLE 1 (cont.)

	Ex. 169	Ex. 170	Ex. 171	Ex. 172	Ex. 173	Ex. 174	Ex. 175	Ex. 176	Ex. 177	Ex. 178	Ex. 179	Ex. 180
FeO (wt.%)	0.2250	0.2250	0.2250	0.1868	0.2730	0.2550	0.2150	0.2365	0.3200	0.2250	0.2870	0.1958
Total iron (wt.%)	0.900	0.900	0.900	0.830	0.840	0.850	0.860	0.860	0.800	0.900	0.820	0.870
Model redox	0.2500	0.2500	0.2500	0.2250	0.3250	0.3000	0.2500	0.2750	0.4000	0.2500	0.3500	0.2250
Cr2O3 (wt.%)	0.0250	0.0250	0.0250	0.0270	0.0280	0.0280	0.0280	0.0280	0.0270	0.0250	0.0270	0.0280
CoO (wt.%)	0.0107	0.0107	0.0107	0.0118	0.0092	0.0097	0.0108	0.0102	0.0079	0.0107	0.0088	0.0113
Se (wt.%)	0.0017	0.0017	0.0017	0.0016	0.0019	0.0018	0.0017	0.0018	0.0020	0.0017	0.0019	0.0017
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.3200						0.1000		
LTA (%)	35.06	35.06	35.06	35.08	35.09	35.09	35.10	35.11	35.11	35.11	35.12	35.13
TSUV (%)	19.75	19.75	19.75	20.17	23.31	22.65	21.54	21.99	25.59	20.29	24.15	20.91
TSIR (%)	24.05	24.05	24.05	29.82	18.43	20.35	25.42	22.54	14.29	24.05	17.08	28.33
TSET (%)	28.37	28.37	28.37	31.58	25.39	26.45	29.23	27.65	23.15	28.45	24.69	30.81
DW (nm)	554.86	554.86	554.86	550.80	550.76	550.70	550.37	550.89	550.75	552.42	551.11	550.97
Pe (%)	4.64	4.64	4.64	3.81	3.93	3.91	3.76	3.92	3.76	4.11	3.79	3.81

TABLE 1 (cont.)

	Ex. 181	Ex. 182	Ex. 183	Ex. 184	Ex. 185	Ex. 186	Ex. 187	Ex. 188	Ex. 189	Ex. 190	Ex. 192	Ex. 192
FeO (wt.%)	0.2228	0.2250	0.2730	0.2568	0.2888	0.2430	0.3040	0.2250	0.2025	0.2250	0.1800	0.2250
Total iron (wt.%)	0.810	0.900	0.780	0.790	0.770	0.810	0.760	0.900	0.900	0.900	0.900	0.900
Model redox	0.2750	0.2500	0.3500	0.3250	0.3750	0.3000	0.4000	0.2500	0.2250	0.2500	0.2000	0.2500
Cr2O3 (wt.%)	0.0260	0.0250	0.0260	0.0265	0.0260	0.0250	0.0255	0.0200	0.0250	0.0250	0.0250	0.0250
CoO (wt.%)	0.0108	0.0107	0.0095	0.0098	0.0089	0.0104	0.0086	0.0107	0.0107	0.0100	0.0107	0.0107
Se (wt.%)	0.0017	0.0017	0.0018	0.0018	0.0019	0.0017	0.0019	0.0017	0.0017	0.0017	0.0017	0.0015
TiO2 (wt.%)	0.3200	0.0200	0.4600	0.2900	0.2700	0.4900	0.4200	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	35.15	35.15	35.16	35.17	35.18	35.20	35.21	35.50	35.59	35.97	36.14	36.14
TSUV (%)	21.34	20.74	22.52	22.73	24.12	20.99	24.01	19.80	19.14	19.76	18.55	20.61
TSIR (%)	24.35	24.05	18.45	20.16	16.93	21.77	15.59	24.07	27.29	24.06	31.00	24.08
TSET (%)	28.67	28.51	25.41	26.39	24.63	27.24	23.87	28.67	30.27	28.68	32.42	28.96
DW (nm)	550.59	549.96	550.81	550.78	550.91	550.73	550.79	554.47	560.86	559.34	564.72	537.17
Pe (%)	3.72	3.69	3.98	3.79	3.73	3.96	3.87	3.99	5.98	5.81	7.33	2.96

TABLE 1 (cont.)

	Ex. 193	Ex. 194	Ex. 195	Ex. 196	Ex. 197	Ex. 198	Ex. 199	Ex. 200	Ex. 201	Ex. 202	Ex. 203	Ex. 204
FeO (wt.%)	0.1750	0.2250	0.2250	0.3500	0.3250	0.1750	0.1750	0.3000	0.1750	0.2250	0.1750	0.2750
Total iron (wt.%)	0.700	0.900	0.900	1.400	1.300	0.700	0.700	1.200	0.700	0.900	0.700	1.100
Model redox	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
Cr2O3 (wt.%)	0.0210	0.0100	0.0005	0.0210	0.0210	0.0210	0.0800	0.0210	0.0700	0.0250	0.0210	0.0210
CoO (wt.%)	0.0070	0.0107	0.0107	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0107	0.0100	0.0070
Se (wt.%)	0.0025	0.0017	0.0017	0.0011	0.0011	0.0020	0.0011	0.0011	0.0011	0.0008	0.0011	0.0011
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	36.15	36.39	37.27	37.74	38.74	39.14	39.29	39.76	40.23	40.24	40.32	40.81
TSUV (%)	20.46	19.92	20.03	15.66	16.96	22.92	27.23	18.38	27.37	23.94	28.00	19.95
TSIR (%)	31.66	24.12	24.16	12.05	13.79	31.74	31.55	15.80	31.61	24.20	31.79	18.13
TSET (%)	32.46	29.28	29.89	22.48	23.95	33.97	33.23	25.58	33.85	31.25	35.55	27.40
DW (nm)	578.76	553.07	549.31	541.05	542.27	575.77	555.78	543.64	555.68	494.01	494.99	545.18
Pe (%)	17.83	2.68	1.44	5.63	5.36	12.83	11.51	5.09	10.21	6.17	3.20	4.83

TABLE 1 (cont.)

	Ex. 205	Ex. 206	Ex. 207	Ex. 208	Ex. 209	Ex. 210	Ex. 211	Ex. 212	Ex. 213	Ex. 214	Ex. 215	Ex. 216
FeO (wt.%)	0.1750	0.2500	0.1750	0.2800	0.1750	0.2625	0.2250	0.2450	0.1750	0.2250	0.2275	0.2000
Total iron (wt.%)	0.700	1.000	0.700	0.700	0.700	0.700	0.900	0.700	0.700	0.900	0.700	0.800
Model redox	0.2500	0.2500	0.2500	0.4000	0.2500	0.3750	0.2500	0.3500	0.2500	0.2500	0.3250	0.2500
Cr2O3 (wt.%)	0.0600	0.0210	0.0500	0.0210	0.0210	0.0210	0.0210	0.0210	0.0400	0.0250	0.0210	0.0210
CoO (wt.%)	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0050	0.0070	0.0070
Se (wt.%)	0.0011	0.0011	0.0011	0.0011	0.0015	0.0011	0.0011	0.0011	0.0011	0.0017	0.0011	0.0011
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
LTA (%)	41.21	41.90	42.22	42.25	42.45	42.74	43.01	43.24	43.27	43.29	43.76	44.16
TSUV (%)	27.52	21.68	27.67	32.61	25.67	31.79	23.59	31.01	27.82	19.88	30.25	25.73
TSIR (%)	31.66	20.83	31.72	17.65	31.82	19.44	23.97	21.44	31.78	24.18	23.65	27.63
TSET (%)	34.49	29.44	35.15	28.68	35.70	29.79	31.73	31.01	35.85	31.10	32.35	34.32
DW (nm)	555.53	546.93	555.32	494.20	569.54	496.90	548.91	501.21	555.00	570.22	509.20	551.16
Pe (%)	8.90	4.57	7.59	4.43	7.81	3.54	4.31	2.70	6.29	14.10	2.01	4.06

TABLE 1 (cont.)

	Ex. 217	Ex. 218	Ex. 219	Ex. 220	Ex. 221	Ex. 222	Ex. 223	Ex. 224	Ex. 225	Ex. 226	Ex. 227	Ex. 228
FeO (wt.%)	0.2100	0.1750	0.1925	0.1750	0.1750	0.2210	0.1440	0.2600	0.2380	0.2100	0.2345	0.1460
Total iron (wt.%)	0.700	0.700	0.700	0.700	0.700	0.680	0.720	0.650	0.680	0.700	0.670	0.730
Model redox	0.3000	0.2500	0.2750	0.2500	0.2500	0.3250	0.2000	0.4000	0.3500	0.3000	0.3500	0.2000
Cr2O3 (wt.%)	0.0210	0.0300	0.0210	0.0210	0.0210	0.0210	0.0240	0.0250	0.0250	0.0255	0.0215	0.0245
CoO (wt.%)	0.0070	0.0070	0.0070	0.0070	0.0070	0.0060	0.0079	0.0047	0.0053	0.0060	0.0057	0.0077
Se (wt.%)	0.0011	0.0011	0.0011	0.0011	0.0011	0.0012	0.0010	0.0013	0.0013	0.0012	0.0012	0.0010
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.8000	0.7000	0.2000	0.2000				0.3000	
LTA (%)	44.28	44.35	44.81	44.95	45.01	45.03	45.04	45.05	45.06	45.07	45.07	45.07
TSUV (%)	29.51	27.97	28.80	23.80	24.47	30.09	26.82	34.11	32.22	30.62	30.22	27.82
TSIR (%)	26.11	31.83	28.84	31.89	31.89	24.54	38.12	19.73	22.30	26.10	22.75	37.68
TSET (%)	33.83	36.57	35.46	36.68	36.77	33.15	40.43	30.51	31.90	33.96	32.14	40.25
DW (nm)	525.66	554.49	543.44	562.94	562.02	550.93	551.27	550.47	550.26	550.86	550.56	550.90
Pe (%)	2.00	4.99	2.82	6.99	6.46	3.55	3.78	3.71	3.76	3.87	3.72	3.59

TABLE 1 (cont.)

	Ex. 229	Ex. 230	Ex. 231	Ex. 232	Ex. 233	Ex. 234	Ex. 235	Ex. 236	Ex. 237	Ex. 238	Ex. 239	Ex. 240
FeO (wt.%)	0.1953	0.1750	0.1725	0.2513	0.1800	0.1750	0.2243	0.1643	0.1750	0.2475	0.2560	0.1750
Total iron (wt.%)	0.710	0.700	0.690	0.670	0.720	0.700	0.690	0.730	0.700	0.660	0.640	0.700
Model redox	0.2750	0.2500	0.2500	0.3750	0.2500	0.2500	0.3250	0.2250	0.2500	0.3750	0.4000	0.2500
Cr2O3 (wt.%)	0.0255	0.0210	0.0230	0.0255	0.0245	0.0210	0.0255	0.0245	0.0210	0.0210	0.0215	0.0210
CoO (wt.%)	0.0064	0.0070	0.0070	0.0049	0.0068	0.0070	0.0056	0.0072	0.0070	0.0054	0.0052	0.0070
Se (wt.%)	0.0011	0.0011	0.0011	0.0013	0.0011	0.0011	0.0012	0.0011	0.0011	0.0012	0.0012	0.0011
TiO2 (wt.%)		0.6000	0.1500			0.5000			0.4000	0.4200	0.5200	0.3000
LTA (%)	45.07	45.08	45.10	45.12	45.13	45.15	45.15	45.17	45.21	45.22	45.27	45.28
TSUV (%)	29.87	25.16	28.73	33.06	29.08	25.86	31.45	28.35	26.59	30.17	30.49	27.34
TSIR (%)	28.38	31.89	32.33	20.71	30.96	31.89	24.08	33.90	31.89	21.16	20.19	31.89
TSET (%)	35.20	36.86	37.40	31.04	36.65	36.96	32.90	38.24	37.05	31.29	30.75	37.15
DW (nm)	550.41	560.95	551.62	550.70	550.88	559.66	550.68	550.94	558.12	550.89	550.76	556.18
Pe (%)	3.79	5.93	3.61	3.88	3.72	5.40	3.87	3.71	4.87	3.90	4.01	4.35

TABLE 1 (cont.)

	Ex. 241	Ex. 242	Ex. 243	Ex. 244	Ex. 245	Ex. 246	Ex. 247	Ex. 248	Ex. 249	Ex. 250	Ex. 251	Ex. 252
FeO (wt.%)	0.1925	0.2070	0.1750	0.1750	0.1750	0.1620	0.1750	0.1750	0.1750	0.1575	0.1400	0.1500
Total iron (wt.%)	0.700	0.690	0.700	0.700	0.700	0.720	0.700	0.700	0.700	0.700	0.700	0.600
Model redox	0.2750	0.3000	0.2500	0.2500	0.2500	0.2250	0.2500	0.2500	0.2500	0.2250	0.2000	0.2500
Cr2^3 (wt.%)	0.0230	0.0210	0.0210	0.0210	0.0210	0.0220	0.0210	0.0200	0.0210	0.0210	0.0210	0.0210
CoO (wt.%)	0.0066	0.0064	0.0070	0.0070	0.0070	0.0075	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070
Se (wt.%)	0.0011	0.0011	0.0011	0.0011	0.0011	0.0010	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
TiO2 (wt.%)	0.2000	0.3800	0.2000	0.2000	0.2000	0.3000	0.1000	0.2000	0.0200	0.2000	0.2000	0.2000
LTA (%)	45.29	45.35	45.35	45.35	45.35	45.35	45.42	45.46	45.47	45.90	46.46	46.57
TSUV (%)	28.78	28.32	28.11	28.11	28.11	26.77	28.90	28.12	29.56	27.44	26.79	30.79
TSIR (%)	28.84	26.57	31.89	31.89	31.89	34.36	31.89	31.89	31.89	35.28	39.06	36.86
TSET (%)	35.54	34.31	37.25	37.25	37.25	38.55	37.35	37.33	37.43	39.23	41.41	40.58
DW (nm)	550.70	550.64	553.71	553.71	553.71	550.30	550.44	553.59	546.98	559.73	563.70	556.63
Pe (%)	3.77	3.80	3.82	3.82	3.82	3.71	3.29	3.69	2.87	4.84	5.88	3.57

TABLE 1 (cont.)

	Ex. 253	Ex. 254	Ex. 255	Ex. 256
FeO (wt.%)	0.1750	0.1750	0.1750	0.1750
Total iron (wt.%)	0.700	0.700	0.700	0.700
Model redox	0.2500	0.2500	0.2500	0.2500
Cr2O3 (wt.%)	0.0100	0.0210	0.0005	0.0210
CoO (wt.%)	0.0070	0.0070	0.0070	0.0050
Se (wt.%)	0.0011	0.0008	0.0011	0.0011
TiO2 (wt.%)	0.2000	0.2000	0.2000	0.2000
LTA (%)	46.61	47.69	47.75	49.07
TSUV (%)	28.28	30.09	28.43	28.18
TSIR (%)	31.95	31.93	32.01	31.95
TSET (%)	38.11	38.53	38.89	38.50
DW (nm)	551.69	509.82	545.77	565.18
Pe (%)	2.39	2.14	1.16	7.39

TABLE 2

	Ex. 257	Ex. 258	Ex. 259	Ex. 260	Ex. 261	Ex. 262	Ex. 263	Ex. 264	Ex. 265
FeO (wt.%)	0.3232	0.2980	0.3080	0.2980	0.3500	0.2890	0.3500	0.3500	0.3080
Total iron (wt %)	1.103	1.103	1.100	1.103	1.083	1.070	1.083	1.083	1.100
Model redox	0.2929	0.2702	0.2800	0.2702	0.3232	0.2701	0.3232	0.3232	0.2800
Cr2O3 (wt.%)	0.0302	0.0302	0.0302	0.0302	0.0293	0.0302	0.0293	0.0293	0.0302
CoO (wt.%)	0.0128	0.0125	0.0128	0.0119	0.0110	0.0119	0.0100	0.0090	0.0100
Se (wt.%)	0.0010	0.0010	0.0010	0.0009	0.0010	0.0009	0.0010	0.0010	0.0010
TiO2 (wt.%)	0.1940	0.1940	0.1940	0.1940	0.3510	0.1940	0.3510	0.3510	0.1940
LTA (%)	31.13	31.95	32.59	33.18	33.47	33.52	34.63	35.84	35.87
TSUV (%)	16.53	15.93	20.62	16.28	19.74	16.79	19.76	19.78	20.69
TSIR (%)	12.31	14.26	13.45	14.27	10.54	15.05	10.54	10.55	13.47
TSET (%)	21.38	22.72	22.93	23.23	21.37	23.84	21.74	22.12	23.98
DW (nm)	497.4	502.2	493.5	502.5	497.8	502.1	502.2	509.2	505.2
Pe (%)	6.57	5.03	6.86	5.14	5.59	5.1	4.52	3.69	3.75

TABLE 3

	Ex. 266	Ex. 267	Ex. 268	Ex. 269
FeO (wt.%)	0.3060	0.3080	0.3400	0.3500
Total iron (wt.%)	1.099	1.103	1.101	1.110
Redox	0.2790	0.2800	0.3100	0.3160
Cr2O3 (wt.%)	0.0286	0.0302	0.0288	0.0323
CoO (wt.%)	0.0128	0.0128	0.0129	0.0129
Se (wt.%)	0.0012	0.0010	0.0008	0.0007
TiO2 (wt.%)	0.3550	0.1940	0.3500	0.1940
LTA (%)	28.33	29.47	29.91	30.25
TSUV (%)	14.14	15.72	16.28	19.16
TSIR (%)	12.99	12.72	10.44	9.31
TSET (%)	19.56	20.12	19.13	18.93
DW (nm)	509.2	497.2	494.2	491.1
Pe (%)	4.06	5.59	8.89	11.88

Referring to Tables 1, 2 and 3, the present invention provides a green colored glass using a standard soda-lime-silica glass base composition and additionally iron, cobalt, selenium and chromium, and optionally titanium, as infrared and ultraviolet radiation absorbing materials and colorants. As may be seen, not all of the examples are the same color, as indicated by the dominant wavelength (DW) and excitation purity (Pe). In the present invention, it is preferred that the glass have a color characterized by a dominant wavelength in the range of about 480 to 565 nanometers, preferably about 495 to 560 nanometers, with an excitation purity of no higher than about 20%, preferably no higher than about 10%, and more preferably no higher than about 7%. It is anticipated that the color of the glass may vary within this dominant wavelength range to provide a desired product. For example, a green blue glass may be produced at a dominant wavelength of about 485 to 515 nanometers, preferably about 490 to 510 nanometers, with an excitation purity of no higher than 10%, preferably not higher than 7%, while a green yellow glass may be produced at a dominant wavelength of about 535 to 565 nanometers, preferably about 540 to 560 nanometers, with an excitation purity of no higher than 10%, preferably not higher than 5%.

The green colored, infrared and ultraviolet radiation absorbing glasses disclosed in the present invention have a luminous transmittance (LTA) of up to 60 percent. In one particular embodiment, the glasses include about 0.6 to 4 wt.% total iron, about 0.13 to 0.9 wt.% FeO, about 40 to 500 PPM CoO, about 5 to 70 PPM Se, about 15 to 800 PPM Cr_2O_3 and 0.02 to about 1 wt.% TiO_2. In another embodiment, the glasses include about 1 to less than 1.4 wt.% total iron, about 0.2 to 0.60 wt.% FeO, greater than 200 to about 500 PPM CoO, about 5 to 70 PPM Se, greater than 200 to about 800 PPM Cr_2O_3 and 0 to about 1 wt.% TiO_2. The redox ratio for these glasses is maintained between about 0.20 to 0.40, preferably between about 0.22 to 0.35, more preferably between about 0.23 to

0.28. These glass compositions also have a TSUV of no greater than about 40%, preferably no greater than about 35%, a TSIR of no greater than about 45%, preferably no greater than about 40%, and a TSET of no greater than about 50%, preferably no greater than about 45%.

The glass compositions of the present invention may be provided with varying levels of spectral performance, depending on the particular application and desired luminous transmittance. In one embodiment of the invention, for a green colored, infrared and ultraviolet radiation absorbing glass having an LTA of less than 20% at at least one thickness in the range of 1.8 to 5.0 mm, the glass composition includes about 1 to less than 1.4 wt.% total iron; about 0.22 to 0.5 wt.%, preferably about 0.3 to 0.5 wt.%; greater than 200 to about 450 PPM CoO, preferably greater than 200 to about 350 PPM; about 10 to 60 PPM Se, preferably about 35 to 50 PPM; about 250 to 400 PPM Cr_2O_3, preferably about 250 to 350 PPM; and 0 to about 1 wt.% TiO_2, preferably about 0.02 to 0.5 wt.%. The glass compositions within this luminous transmittance range have a TSUV of no greater than about 30%, preferably no greater than 12%, a TSIR of no greater than about 35%, preferably no greater than about 20%, and a TSET of no greater than about 30%, preferably no greater than about 20%.

In another embodiment of the invention, for a green colored, infrared and ultraviolet radiation absorbing glass having an LTA of less than 20 to 60% at at least one thickness in the range of 1.8 to 5.0 mm, the glass composition includes about 1 to less than 1.4 wt.% total iron; about 0.25 to 0.4 wt.%; greater than 200 to about 250 PPM CoO; about 10 to 30 PPM Se; greater than 200 to about 250 PPM Cr_2O_3, preferably about 250 to 350 PPM; and about 0.02 to 0.5 wt.% TiO_2. The glass compositions within this luminous transmittance range have a TSUV of no greater than about 35%, preferably no greater than 20%, a TSIR of no greater than about 40%, preferably no greater than about 15% and a TSET of no greater than about 45%, preferably, no greater than about 25%.

In another embodiment of the invention, for a green colored, infrared and ultraviolet radiation absorbing glass having an LTA of 20 to 60% at a reference thickness of 4.06 mm, the glass composition includes greater than 0.7 to about 2 wt.% total iron, preferably about 0.8 to 1.5 wt.%; about 0.13 to 0.6 wt.% FeO, preferably about 0.14 to 0.43 wt.%; greater than 200 to about 300 PPM CoO, preferably greater than 200 to about 250 PPM; about 5 to 70 PPM Se, preferably about 8 to 60 PPM; greater than 200 to about 300 PPM Cr_2O_3, preferably greater than 200 to about 250 PPM; and 0 to about 1 wt.% TiO_2, preferably about 0.02 to 0.5 wt.%. The glass compositions within this luminous transmittance range have a TSUV of no greater than about 35%, a TSIR of no greater than about 40%, and a TSET of no greater than about 45%.

In another embodiment of the invention, the green colored, infrared and ultraviolet radiation absorbing glass composition includes 0.9 to 1.3 wt.% total iron, preferably 1.083 to 1.11 wt.%; 0.25 to 0.40 wt.% FeO, preferably 0.306 to 0.35 wt.%; 80 to 130 PPM CoO, preferably 90 to 128 PPM; 8 to 15 PPM Se, preferably 10 to 12 PPM; 250 to 350 PPM Cr_2O_3, preferably 286 to 302 PPM; and 0.1 to 0.5 wt.% TiO_2, preferably 0.194 to 0.355 wt.%. These glasses have a luminous transmittance (LTA) of 25 to 40 percent, a total solar ultraviolet transmittance (TSUV) of about 25 percent or less, a total solar infrared transmittance (TSIR) of about 20 percent or less and a total solar energy transmittance (TSET) of about 30 percent or less.

It is expected that the spectral properties of the glass compositions disclosed herein will change after tempering the glass and further upon prolonged exposure to ultraviolet radiation, commonly referred to as solarization. In particular, it is believed that tempering and solarization of the glass compositions disclosed herein will increase the LTA and reduce the TSUV, TSIR and TSET. As a result, in one embodiment of the invention, a glass composition may have selected spectral properties that initially fall outside the

desired ranges previously discussed but fall within the desired ranges after tempering and/or solarization.

Glass made by the float process typically ranges from a sheet thickness of about 1 millimeters to 10 millimeters. For vehicle glazing applications, it is preferred that the glass sheets having a composition and spectral properties as disclosed herein have a thickness within the range of 0.071 to 0.197 inches (1.8 to 5 mm). It is anticipated that when using a single glass ply, the glass will be tempered, e.g. for an automotive side or rear window, and when multiple plies are used, the glass will be annealed and laminated together using a thermoplastic adhesive, such as polyvinyl butyral.

It is contemplated that vanadium may be used as a partial or complete replacement for the chromium in the glass compositions of the present inventions. More specifically, vanadium, which is expressed herein in terms of V_2O_5, imparts a yellow-green color to the glass and absorbs both ultraviolet and infrared radiation at different valence states. It is believed that Cr_2O_3 in the range of about 25 to 800 PPM discussed above may be completely replaced by about 0.01 to 0.32 wt.% V_2O_5.

As discussed earlier, other materials may also be added to the glass compositions disclosed herein to further reduce infrared and ultraviolet radiation transmission and/or control glass color. In particular, it is contemplated that the following materials may be added to the iron, cobalt, selenium, chromium and titanium containing soda-lime-silica glass disclosed herein:

MnO_2	0 to 0.5 wt.%
SnO_2	0 to 2 wt.%
ZnO	0 to 0.5 wt.%
Nd_2O_3	0 to about 0.5 wt.%
Mo	0 to 0.015 wt.%
CeO_2	0 to 2 wt.%
NiO	0 to 0.1 wt.%

CuO	0 to 2 wt % with a reduction in the amount of CoO of 1 ppm for every 6 ppm of CuO

As should be appreciated, adjustments may have to be made to the basic iron, cobalt, selenium, chromium and/or titanium constituents to account for any coloring and/or redox affecting power of these additional materials.

Depending on the type of melting operation, sulfur may be added to the batch materials of a soda-lime-silica glass as a melting and refining aid. Commercially produced float glass may include up to about 0.3 wt.% SO_3. In a glass composition that includes iron and sulfur, providing reducing conditions may create amber coloration which lowers luminous transmittance as discussed in U.S. Patent No. 4,792,536 to Pecoraro, et al. However, it is believed that the reducing conditions required to produce this coloration in float glass compositions of the type disclosed herein are limited to approximately the first 20 microns of the lower glass surface contacting the molten tin during the float forming operation, and to a lesser extent, to the exposed upper glass surface. Because of the low sulfur content and the limited region of the glass in which any coloration could occur, depending on the particular soda-lime-silica-glass composition, sulfur in these surfaces has little if any material effect on the glass color or spectral properties.

Other variations as are known to those skilled in the art may be resorted to without departing from the scope of the invention as defined by the claims that follow.

WE CLAIM:

1. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	about 66 to 75 percent by weight,
Na_2O	about 10 to 20 percent by weight,
CaO	about 5 to 15 percent by weight,
MgO	0 to about 5 percent by weight,
Al_2O_3	0 to about 5 percent by weight,
K_2O	0 to about 5 percent by weight,

and a solar radiation absorbing and colorant portion comprising:

total iron	about 0.60 to 4 percent by weight,
FeO	about 0.13 to 0.9 percent by weight,
CoO	about 40 to 500 PPM,
Se	about 5 to 70 PPM,
Cr_2O_3	about 15 to 800 PPM, and
TiO_2	about 0.02 to 1 percent by weight,

the glass having a luminous transmittance (LTA) of up to about 60 percent, a total solar ultraviolet transmittance (TSUV) of about 40 percent or less, a total solar infrared transmittance (TSIR) of about 45 percent or less and a total solar energy transmittance (TSET) of about 50 percent or less.

2. The article as in claim 1 wherein the glass has a redox of about 0.2 to 0.4.

3. The article as in claim 1 wherein the glass has a total solar ultraviolet transmittance (TSUV) of about 40 percent or less, a total solar infrared transmittance (TSIR) of about 45 percent or less and a total solar energy transmittance (TSET) of about 50 percent or less.

4. The article as in claim 3 wherein the glass has a total solar ultraviolet transmittance (TSUV) of about 35

percent or less, a total solar infrared transmittance (TSIR) of about 40 percent or less and a total solar energy transmittance (TSET) of about 45 percent or less.

5. The article as in claim 1 wherein the color of the glass is characterized by a dominant wavelength in the range of about 480 to 565 nanometers and an excitation purity of no higher than about 20 percent.

6. The article as in claim 5 wherein the color of the glass is characterized by a dominant wavelength in the range of about 485 to 515 nanometers and an excitation purity of no higher than about 10 percent.

7. The article as in claim 6 wherein the color of the glass is characterized by a dominant wavelength in the range of about 490 to 510 nanometers and an excitation purity of no higher than about 7 percent.

8. The article as in claim 5 wherein the color of the glass is characterized by a dominant wavelength in the range of about 535 to 565 nanometers and an excitation purity of no higher than about 10 percent.

9. The article as in claim 8 wherein the color of the glass is characterized by a dominant wavelength in the range of about 540 to 560 nanometers and an excitation purity of no higher than about 5 percent.

10. The article as in claim 1 wherein the glass has a luminous transmittance of less than 20 percent at at least one thickness in the range of 1.8 to 5.0 mm.

11. The article as in claim 1 wherein the glass has a luminous transmittance of 20 to 60 percent at at least one thickness in the range of 1.8 to 5.0 mm.

12. The article as in claim 1 comprising a flat glass sheet.

13. The article as in claim 12 wherein said sheet has traces of tin oxide in a surface portion.

14. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	about 66 to 75 percent by weight,
Na_2O	about 10 to 20 percent by weight,
CaO	about 5 to 15 percent by weight,
MgO	0 to about 5 percent by weight,
Al_2O_3	0 to about 5 percent by weight,
K_2O	0 to about 5 percent by weight,

and a solar radiation absorbing and colorant portion comprising:

total iron	1 to less than 1.4 percent by weight,
FeO	about 0.2 to 0.6 percent by weight,
CoO	greater than 200 to about 500 PPM,
Se	about 5 to 70 PPM,
Cr_2O_3	greater than 200 to about 800 PPM, and
TiO_2	0 to about 1 percent by weight,

the glass having a luminous transmittance (LTA) of up to about 60 percent, a total solar ultraviolet transmittance (TSUV) of about 40 percent or less, a total solar infrared transmittance (TSIR) of about 45 percent or less and a total solar energy transmittance (TSET) of about 50 percent or less.

15. The article as in claim 14 wherein the glass has a redox of about 0.2 to 0.4.

16. The article as in claim 14 wherein the glass has a total solar ultraviolet transmittance (TSUV) of about 40 percent or less, a total solar infrared transmittance (TSIR)

of about 45 percent or less and a total solar energy transmittance (TSET) of about 50 percent or less.

17. The article as in claim 16 wherein the glass has a total solar ultraviolet transmittance (TSUV) of about 35 percent or less, a total solar infrared transmittance (TSIR) of about 40 percent or less and a total solar energy transmittance (TSET) of about 45 percent or less.

18. The article as in claim 14 wherein the color of the glass is characterized by a dominant wavelength in the range of about 480 to 565 nanometers and an excitation purity of no higher than about 20 percent.

19. The article as in claim 18 wherein the color of the glass is characterized by a dominant wavelength in the range of about 485 to 515 nanometers and an excitation purity of no higher than about 10 percent.

20. The article as in claim 19 wherein the color of the glass is characterized by a dominant wavelength in the range of about 490 to 510 nanometers and an excitation purity of no higher than about 7 percent.

21. The article as in claim 18 wherein the color of the glass is characterized by a dominant wavelength in the range of about 535 to 565 nanometers and an excitation purity of no higher than about 10 percent.

22. The article as in claim 21 wherein the color of the glass is characterized by a dominant wavelength in the range of about 540 to 560 nanometers and an excitation purity of no higher than about 5 percent.

23. The article as in claim 14 wherein the glass has a luminous transmittance of less than 20 percent at at least one thickness in the range of 1.8 to 5.0 mm.

24. The article as in claim 23 wherein the FeO concentration is from about 0.22 to 0.5 weight percent, the CoO concentration is greater than 200 to about 450 PPM, the Se concentration is about 10 to 60 PPM, the Cr_2O_3 concentration is about 250 to 400 PPM, and the TiO_2 concentration is about 0.02 to 0.5 weight percent.

25. The article as in claim 24 wherein the FeO concentration is from about 0.3 to 0.5 weight percent, the CoO concentration is greater than 200 to about 350 PPM, the Se concentration is about 35 to 50 PPM, and the Cr_2O_3 concentration is about 250 to 350 PPM.

26. The article as in claim 24 wherein the glass has a total solar ultraviolet transmittance (TSUV) of about 30 percent or less, a total solar infrared transmittance (TSIR) of about 35 percent or less and a total solar energy transmittance (TSET) of about 30 percent or less.

27. The article as in claim 26 wherein the glass has a total solar ultraviolet transmittance (TSUV) of about 12 percent or less, a total solar infrared transmittance (TSIR) of about 20 percent or less and a total solar energy transmittance (TSET) of about 20 percent or less.

28. The article as in claim 24 wherein the color of the glass is characterized by a dominant wavelength in the range of about 480 to 565 nanometers and an excitation purity of no higher than about 20 percent.

29. The article as in claim 28 wherein the color of the glass is characterized by a dominant wavelength in the range

of about 540 to 560 nanometers and an excitation purity of no higher than about 5 percent.

30. The article as in claim 14 wherein the glass has a luminous transmittance of 20 to 60 percent at at least one thickness in the range of 1.8 to 5.0 mm.

31. The article as in claim 30 wherein the FeO concentration is from about 0.25 to 0.4 weight percent, the CoO concentration is greater than 200 to about 250 PPM, the Se concentration is about 10 to 30 PPM, the Cr_2O_3 concentration is greater than 200 to about 250 PPM, and the TiO_2 concentration is about 0.02 to 0.5 weight percent.

32. The article as in claim 31 wherein the glass has a total solar ultraviolet transmittance (TSUV) of about 35 percent or less, a total solar infrared transmittance (TSIR) of about 40 percent or less and a total solar energy transmittance (TSET) of about 45 percent or less.

33. The article as in claim 32 wherein the glass has a total solar ultraviolet transmittance (TSUV) of about 20 percent or less, a total solar infrared transmittance (TSIR) of about 15 percent or less and a total solar energy transmittance (TSET) of about 25 percent or less.

34. The article as in claim 31 wherein the color of the glass is characterized by a dominant wavelength in the range of about 480 to 565 nanometers and an excitation purity of no higher than about 20 percent.

35. The article as in claim 34 wherein the color of the glass is characterized by a dominant wavelength in the range of about 490 to 510 nanometers and an excitation purity of no higher than about 7 percent.

36. The article as in claim 14 comprising a flat glass sheet.

37. The article as in claim 36 wherein said sheet has traces of tin oxide in a surface portion.

38. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	about 66 to 75 percent by weight,
Na_2O	about 10 to 20 percent by weight,
CaO	about 5 to 15 percent by weight,
MgO	0 to about 5 percent by weight,
Al_2O_3	0 to about 5 percent by weight,
K_2O	0 to about 5 percent by weight,

and a solar radiation absorbing and colorant portion comprising:

total iron greater than 0.7 to about 2 percent by weight,

FeO	about 0.13 to 0.6 percent by weight,
CoO	greater than 200 to about 300 PPM,
Se	5 to 70 PPM,
Cr_2O_3	greater than 200 to about 300 PPM, and
TiO_2	0 to about 1 percent by weight,

the glass having a luminous transmittance (LTA) of 20 to 60 percent, a total solar ultraviolet transmittance (TSUV) of about 35 percent or less, a total solar infrared transmittance (TSIR) of about 40 percent or less and a total solar energy transmittance (TSET) of about 45 percent or less at a reference thickness of 4.06 mm, wherein the color of the glass is characterized by a dominant wavelength in the range of about 480 to 565 nanometers and an excitation purity of no higher than about 20 percent.

39. The article as in claim 38 wherein the total iron concentration is from about 0.8 to 1.5 weight percent, the FeO

concentration is from about 0.14 to 0.43 weight percent, the CoO concentration is greater than 200 to about 250 PPM, the Se concentration is about 8 to 60 PPM, the Cr_2O_3 concentration is greater than 200 to about 250 PPM, and the TiO_2 concentration is about 0.02 to 0.5 weight percent.

40. The article as in claim 38 wherein the glass has a total solar ultraviolet transmittance (TSUV) of about 35 percent or less, a total solar infrared transmittance (TSIR) of about 40 percent or less and a total solar energy transmittance (TSET) of about 45 percent or less.

41. The article as in claim 38 wherein the color of the glass is characterized by a dominant wavelength in the range of about 480 to 565 nanometers and an excitation purity of no higher than about 20 percent.

42. The article as in claim 41 wherein the color of the glass is characterized by a dominant wavelength in the range of about 490 to 510 nanometers and an excitation purity of no higher than about 7 percent.

43. The article as in claim 38 wherein the glass has a redox of about 0.2 to 0.4.

44. The article as in claim 38 comprising a flat glass sheet.

45. The article as in claim 44 wherein said sheet has traces of tin oxide in a surface portion.

46. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	about 66 to 75 percent by weight,
Na_2O	about 10 to 20 percent by weight,

CaO	about 5 to 15 percent by weight,
MgO	0 to about 5 percent by weight,
Al_2O_3	0 to about 5 percent by weight,
K_2O	0 to about 5 percent by weight,

and a solar radiation absorbing and colorant portion comprising:

total iron	0.9 to 1.3 percent by weight,
FeO	0.25 to 0.40 percent by weight,
CoO	80 to 130 PPM,
Se	8 to 15 PPM,
Cr_2O_3	250 to 350 PPM, and
TiO_2	0.1 to 0.5 percent by weight,

the glass having a luminous transmittance (LTA) of 25 to 40 percent.

47. The article as in claim 46 wherein the total iron concentration is from about 1.083 to 1.11 weight percent, the FeO concentration is from about 0.306 to 0.35 weight percent, the CoO concentration is 90 to 128 PPM, the Se concentration is about 10 to 12 PPM, the Cr_2O_3 concentration is 286 to 302 PPM, and the TiO_2 concentration is 0.194 to 0.355 weight percent.

48. The article as in claim 47 wherein the glass has a total solar ultraviolet transmittance (TSUV) of about 25 percent or less, a total solar infrared transmittance (TSIR) of about 20 percent or less and a total solar energy transmittance (TSET) of about 30 percent or less.

49. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	about 66 to 75 percent by weight,
Na_2O	about 10 to 20 percent by weight,
CaO	about 5 to 15 percent by weight,
MgO	0 to about 5 percent by weight,

Al_2O_3	0 to about 5 percent by weight,
K_2O	0 to about 5 percent by weight,

and a solar radiation absorbing and colorant portion comprising:

total iron	about 0.6 to 4 percent by weight,
FeO	about 0.13 to 0.9 percent by weight,
CoO	about 40 to 500 PPM,
Se	about 5 to 70 PPM,
TiO_2	about 0.02 to 1 percent by weight,
Cr_2O_3	0 to about 0.08 percent by weight,
V_2O_5	0 to about 0.32 percent by weight,
MnO_2	0 to about 0.5 percent by weight,
SnO_2	0 to about 2 percent by weight,
ZnO	0 to about 0.5 percent by weight,
Mo	0 to about 0.015 percent by weight,
CeO_2	0 to about 2 percent by weight,
NiO	0 to about 0.1 percent by weight,

wherein the sum of the Cr_2O_3 concentration plus 25 percent of the V_2O_5 concentration is at least 0.0015 percent by weight, and the glass has a luminous transmittance (LTA) of up to 60 percent.

50. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	about 66 to 75 percent by weight,
Na_2O	about 10 to 20 percent by weight,
CaO	about 5 to 15 percent by weight,
MgO	0 to about 5 percent by weight,
Al_2O_3	0 to about 5 percent by weight,
K_2O	0 to about 5 percent by weight,

and a solar radiation absorbing and colorant portion comprising:

total iron	1 to less than 1.4 percent by weight,
FeO	about 0.2 to 0.6 percent by weight,
CoO	greater than 200 to about 450 PPM,

Se	about 5 to 70 PPM,
TiO_2	0 to about 1 percent by weight,
Cr_2O_3	0 to about 0.08 percent by weight,
V_2O_5	0 to about 0.32 percent by weight,
MnO_2	0 to about 0.5 percent by weight,
SnO_2	0 to about 2 percent by weight,
ZnO	0 to about 0.5 percent by weight,
Mo	0 to about 0.015 percent by weight,
CeO_2	0 to about 2 percent by weight,
NiO	0 to about 0.1 percent by weight,

wherein the sum of the Cr_2O_3 concentration plus 25 percent of the V_2O_5 concentration is at least 0.0200 percent by weight, and the glass has a luminous transmittance (LTA) of up to 60 percent.

51. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	about 66 to 75 percent by weight,
Na_2O	about 10 to 20 percent by weight,
CaO	about 5 to 15 percent by weight,
MgO	0 to about 5 percent by weight,
Al_2O_3	0 to about 5 percent by weight,
K_2O	0 to about 5 percent by weight,

and a solar radiation absorbing and colorant portion of:

total iron	about 0.60 to 4 percent by weight,
FeO	about 0.13 to 0.9 percent by weight,
CoO	about 40 to 500 PPM,
Se	about 5 to 70 PPM,
Cr_2O_3	about 15 to 800 PPM, and
TiO_2	about 0.02 to 1 percent by weight for

ultraviolet radiation absorption and for imparting a yellow color to the glass composition, wherein these solar radiation absorbing and colorant materials are balanced in amounts to obtain the green colored glass having a luminous transmittance (LTA) of up to about 60 percent and a total solar energy

transmittance (TSET) of about 50 percent or less, a total solar ultraviolet transmittance (TSUV) of about 40 percent or less, and a total solar infrared transmittance (TSIR) of about 45 percent or less.

52. A green colored, infrared and ultraviolet radiation absorbing glass article having a composition comprising a base glass portion comprising:

SiO_2	about 66 to 75 percent by weight,
Na_2O	about 10 to 20 percent by weight,
CaO	about 5 to 15 percent by weight,
MgO	0 to about 5 percent by weight,
Al_2O_3	0 to about 5 percent by weight,
K_2O	0 to about 5 percent by weight,

and a solar radiation absorbing and colorant portion of major colorants consisting essentially of:

total iron	about 0.60 to 4 percent by weight,
FeO	about 0.13 to 0.9 percent by weight,
CoO	about 40 to 500 PPM,
Se	about 5 to 70 PPM,
Cr_2O_3	about 15 to 800 PPM, and
TiO_2	about 0.02 to 1 percent by weight,

the glass having a luminous transmittance (LTA) of up to about 60 percent.

INTERNATIONAL SEARCH REPORT

Intern. nal Application No
PCT/US 00/22558

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C03C3/087 C03C4/02 C03C4/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C03C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 816 296 A (PPG INDUSTRIES INC) 7 January 1998 (1998-01-07) claims; examples	1-52
X	EP 0 936 197 A (PPG INDUSTRIES INC) 18 August 1999 (1999-08-18) claims; examples	1-52
X	EP 0 802 168 A (GUARDIAN INDUSTRIES) 22 October 1997 (1997-10-22) claims; examples	1-52
X	EP 0 798 271 A (ASAHI GLASS CO LTD) 1 October 1997 (1997-10-01) claims; examples	1-52

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 November 2000	28/11/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Van Bommel, L

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Intern. .ial Application No
PCT/US 00/22558

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 28254 A (PPG INDUSTRIES INC) 10 June 1999 (1999-06-10) claims; examples page 5, line 6 - line 20	1-52

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern. .nal Application No
PCT/US 00/22558

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0816296 A	07-01-1998	AU 691144 B	07-05-1998
		AU 2843797 A	05-02-1998
		BR 9702552 A	10-11-1998
		CA 2209122 A	02-01-1998
		CN 1176230 A	18-03-1998
		EP 0936197 A	18-08-1999
		JP 10114539 A	06-05-1998
		KR 241647 B	01-02-2000
		NZ 328222 A	25-03-1998
EP 0936197 A	18-08-1999	AU 691144 B	07-05-1998
		AU 2843797 A	05-02-1998
		BR 9702552 A	10-11-1998
		CA 2209122 A	02-01-1998
		CN 1176230 A	18-03-1998
		EP 0816296 A	07-01-1998
		JP 10114539 A	06-05-1998
		KR 241647 B	01-02-2000
		NZ 328222 A	25-03-1998
EP 0802168 A	22-10-1997	US 5932502 A	03-08-1999
		AU 722356 B	27-07-2000
		AU 1900497 A	23-10-1997
		BR 9701876 A	29-09-1998
		CA 2202804 A	19-10-1997
		CZ 9701201 A	17-12-1997
		JP 10120431 A	12-05-1998
		PL 319548 A	27-10-1997
EP 0798271 A	01-10-1997	JP 9315835 A	09-12-1997
		US 5905047 A	18-05-1999
WO 9928254 A	10-06-1999	US 6103650 A	15-08-2000
		AU 1465199 A	16-06-1999
		BR 9814668 A	03-10-2000
		EP 1034144 A	13-09-2000